

High Dispersion Observations of Venus During 1972

The CO₂ band at 7820⁰Å

by

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Abstract

Forty-seven well-exposed photographic plates of Venus which show the spectrum of the carbon dioxide band at 7820\AA were obtained at Table Mountain Observatory in September-October 1972. These spectra showed a semi-regular 4-day variation in the CO_2 abundance over the disk of the planet (Young et. al. 1974). We also find evidence for temporal variations in the rotational temperature of this band and temperature variations over the disk. The two quantities, CO_2 abundance and temperature, do not show any obvious relationship; however, an increase in the temperature usually is accompanied by a decrease in the abundance of CO_2 . The average temperature, found from a curve of growth analysis assuming a constant CO_2 line of width, is $249 \pm 1.4^\circ\text{K}$ (one standard deviation). This temperature is noticeably higher than the rotational temperature of $242 \pm 2^\circ\text{K}$ found for this same band in 1967 (Schorn et. al. 1969) and of $242 \pm 1.2^\circ\text{K}$ in 1968-9 (Young et. al. 1971).

I. Introduction

For the past 9 years there has been a spectroscopic patrol of Venus, to monitor the apparent abundance of carbon dioxide visible in reflected sunlight above her cloud tops and to measure the rotational temperature of the CO_2 (See Young, 1972). This patrol began, and continues, at McDonald Observatory; observations have also been made more recently at Table Mountain Observatory. The 24-inch telescope at Table Mountain provides a relatively small image of the planet, compared to that of either the 82-inch or 107-inch telescopes at McDonald Observatory. As a result the Table Mountain observations were mainly intended to monitor daily changes at a few standard slit positions; areal coverage over the planet was restricted. On the other hand, the dispersion of the plates obtained at Table Mountain ($1.6\text{\AA}/\text{mm}$) was somewhat higher than that of the best plates previously obtained at McDonald Observatory ($\sim 2\text{\AA}/\text{mm}$).

In September of 1972, an intensive spectroscopic patrol of Venus was simultaneously undertaken at both Table Mountain and McDonald Observatories. These observations were made in cooperation with the Paris, New Mexico State University and Lowell Observatories, where ultraviolet photographs of cloud marking were taken. This was the first extensive effort made to observe Venus in both the ultraviolet and infrared regions of the spectrum over a fairly long time interval (3 weeks). One difficulty, in the past, had been the comparative lack of overlap of the dates of observation for the planetary patrols in the two spectral regions. This paper will only be concerned with the results of the Table Mountain observations of the CO_2 band at 7820\AA . When the results from the other observations are published, we shall see if any correlation exists between our results and theirs.

2. Observations and Measurements

The spectrograms used in this study are listed in Table 1. The plate number is given in column 1. When more than one spectrum was taken on one plate (as was usually the case, to conserve plates) successive spectra are denoted by the suffixes a, b, and c. The spectra were taken at the coude focus of the 24-inch telescope. The spectrograph has been described by Young and Young (1972). The 7820Å spectra were taken in 4th order (1.6Å/mm) through a RG-715 filter. A typical exposure time of 30 minutes was required. Columns 2 and 3 of Table 1 give the date and time of the observations. Column 4 gives the slit orientation. We have followed the numbering scheme of Schorn et. al. (1969) to indicate the six standard* slit positions used in this set of observations: 1) pole-to-pole near the terminator; 2) pole-to-pole near the limb; 3) parallel to the equator near the South Pole; 4) parallel to the equator near the sub-Earth Point; 5) parallel to the equator near the North pole; 6) Parallel to the line joining the cusps and midway between limb and terminator. The last position of the slit was adopted as "standard" because it produced spectra of the greatest width and uniformity. On days when local weather conditions were such that it appeared we would be lucky to get one spectrum of Venus, we always used this "standard" slit position. Our seeing estimates are given in Column 5 (for comparison we note that the diameter of Venus during this period was about 18 seconds of arc).

* In Table 5, a slightly more refined scheme is used to indicate the slit position on Venus. The information given in Table 1 is meant to facilitate a comparison of the present results with those of Schorn et. al. (1969).

In our preliminary paper, (Young et. al., 1974) the photographic and photometric procedures we used were described in great detail. In summary, all the Table Mountain spectra were taken on ammonia-hypersensitized IV-N plates, developed for 14 minutes in D-76 with vigorous agitation. Spot plates were taken at the same time, for the same length of exposure, and developed with the Venus plates. The spectra were traced in the density mode, which for IV-N plates amounts to a direct intensity tracing.

All three authors measured the heights (in mm) of 11 solar lines and 25 CO₂ lines for each tracing of a Venus spectrum. The average sum of the heights of the solar lines in mm, is given in Column 6. Column 7 gives the ratio, R, of the average sum of the heights of the CO₂ lines (in mm) to the average sum of the heights of the solar lines (in mm). This quantity, R, was used in our preliminary paper as a measure of the relative abundance of CO₂. The main reason for using this ratio was to eliminate the uncertainty in the conversion from square counts to mÅ for the equivalent widths of the carbon dioxide lines. The heights of the CO₂ lines are directly proportional to their equivalent widths; the Venusian lines are narrow compared to the instrumental width so the apparent "line profile" is, in fact, the instrumental slit function.

On the other hand, the solar lines are generally much broader than the slit width and their line shape is usually well resolved. Whether or not the solar lines were completely resolved does not affect the CO₂ abundance ratio for the following reason: All the Venus plates were taken with an identical slit width for the spectrograph and were always traced using the same slit width for the microdensitometer. Thus the ratios, R, were all affected by the same instrumental effects, and are "good" measures of the CO₂ abundance variations. Obviously the choice of different instrumental parameters would affect the numerical value of the ratios, but not their usefulness in sensing small changes in the CO₂ abundance.

Because the height of the CO₂ lines is directly proportional to their equivalent width, one can use these heights directly to obtain the rotational temperature for a particular spectrum. And that is what was done in this paper. However, in order to compare these results with other measurements on the 7820Å band, it is necessary to convert the heights of the CO₂ lines to equivalent widths in mÅ. This calibration was done using the solar lines given in Table II. We have used the equivalent widths of the solar lines given by Moore et. al. (1966), out of necessity, but the equivalent widths measured by Barker and Perry for integrated sunlight are in fact the appropriate ones for our Venus spectra. As can be seen from Table II, the average rms difference in the two measurements of solar equivalent widths is 13.4 percent, while the difference in the sum of the five lines is 208.2 - 209.0 mÅ or only 0.4 percent. Our usual calibration procedure has been to use the average of the conversion factors (from mm² of chart paper to mÅ) found from the sum of the solar lines and that obtained from the individual solar lines. In view of Barker and Perry's new measurements, it would appear that the conversion factor obtained from the sum of the equivalent widths is the better one to use. This sum equals 429mÅ for the solar calibration lines given in Table II. Table I gives the sum of the heights of these solar lines for each plate. The equivalent width of a Venus line is given by

$$W_{\odot} = h_{\odot} (b_{\odot}/b_{\oplus}) (\Sigma W_{\oplus} / \Sigma h_{\oplus}), \quad (1)$$

where h is the height of the line and b is the base of a triangular shaped line of equivalent width W. The ratio $(b_{\odot}/b_{\oplus}) = 2/3$ for our data.

III Determination of Rotational Temperatures and other parameters.

The rotational temperature can be found if we assume that the curve of growth can be locally approximated by a straight line of slope, b, i.e.

$$W(m) \propto S(m)^b \quad (2)$$

where m is the rotational line index. The index m is related to the rotational quantum number of the lower state, J'' , by $m = -J''$ for the P branch of a band and $m = J'' + 1$ for the R branch. The intensity of a rotational line in the 7820Å band of CO_2 is given by

$$S(m) = (S_v/Q_{\text{rot}}) |m| \exp(-hcBm(m-1)/kT) \quad (3)$$

where S_v is the band intensity (equal to the sum of the individual rotational line intensities), Q_{rot} is the rotational partition function, $(hcB/k) = 0.5614$ for this band and T is the rotational temperature. From equations (2) and (3) we see that

$$\ln [W(m)/m^b] = \ln W_0 - [0.5614m(m-1)b/T]$$

where W_0 corresponds to the equivalent width of the R0 line; depending upon the pressure, temperature and amount of absorbing gas where the lines are formed, W_0 will be a function of the amount of absorbing gas and may also be a function of the effective pressure for line formation, etc.

In a linear least-squares fit to (4), the rotational temperature is determined for a particular value of b ; the quantity W_0 is merely the intercept of this line, and it will be equal to the measured equivalent width of the R0 CO_2 line only if the best fit to all the CO_2 lines in the band goes through R0. However, W_0 is a convenient measure of the CO_2 abundance.

For historical reasons, we first compute the rotational temperature assuming a square-root absorption law, $b = 0.5$. The results of these computations are given in Column 2 of Table 3, for each of the three authors' measurements. The individuals are identified by a single initial following the plate number given in Column 1: G = LDGY, Y = ATY, and W = AW. In Column 3, the quantity W_0 is given; this has been converted to mÅ by the calibration scheme discussed previously. In Figs. 1 to 16 each individual's measurements of the heights of the Venus lines, in mm, are shown. We have done this in preference to converting

these heights to $m\text{\AA}$, because we have come to doubt the accuracy of our absolute calibration and believe the relative measurements are more accurate. In Column 4 we give the percentage standard deviation in the heights (or equivalent widths) as found from the square-root curve of growth temperature fit.

The assumption of a square-root absorption law is the first in a series of iterations where b and hence $T(b)$ are allowed to vary. The quantity T_0 (given in Column 9 of Table 3) is the temperature for which line intensities are computed from equation (3) to be used for the curve of growth indicated by equation (2). As an example of how this iterative scheme works, we show, in Table 4, the intermediate results found for a typical plate.

The first column of Table 4 shows what happens when we assume $T_0 = 240^\circ\text{K}$. Columns 2 to 4 give the temperatures found from each author's measurements of plate T660B. Columns 5 to 7 give the standard deviation of the heights (or equivalent width) obtained from the temperature fit. Columns 8 to 11 give the differences between $T(b)$ and the assumed value of T_0 . The values of $T(b)$ are seen to be higher than T_0 , suggesting that T_0 should be increased. When T_0 is increased to 250°K , both the standard deviation in the heights and $\Delta T = T(b) - T_0$ decrease. At this point a familiar problem crops up. One person's measurements suggest that T_0 should be increased further, while the other two individuals' measurements suggest it should be decreased slightly. We want to use the same value of T_0 for any given spectrum and not allow it to vary from one person's measurements to another, since all three measurements are combined to find the average value of $T(b)$ from a least-squares fit to all the data. Increasing T_0 from 250°K to 260°K gives a good fit to one person's measurements, but a poor fit to the measurements of the other two people. The temperature, T_0 , which shows the minimum sum of the standard deviations (or ΔT) is chosen as the "best" value of T_0 .

The values of b (the slope of the curve of growth) and $T(b)$ are given in Columns 5 and 6 of Table 3. Column 7 gives $W_o(b)$, converted from heights to $m\text{\AA}$; the standard deviation of $W_o(b)$ is given in Column 8.

Table 5 summarizes our final results. The exact slit position for each spectrum is given in Column 2; the remainder of Table 5 resembles Table 3 in layout.

The histogram of the final temperatures, $T(b)$, is shown in Fig. 17. We note that the external spread of the individual temperature determinations, σ_{ext} , is significantly larger than the average internal precision of a single temperature determination, σ_{int} , which is given by the least-squares solutions for T . These data are the first examples of a significant temperature spread detected in the 7820\AA CO_2 band; earlier data (Young et al., 1971; Schorn et al., 1969) gave essentially equal values of σ_{int} and σ_{ext} .

At the end of Table 5 we give the errors in the mean found from both σ_{int} and σ_{ext} for each region on the planet. If σ_{ext} is markedly larger than σ_{int} for a region, a real variation in temperature is indicated. If σ_{ext} is less than σ_{int} , which usually happens only if a few spectra cover that region, the external agreement must be regarded as fortuitous, and the larger value (σ_{int}) must be taken as a more reliable estimate of the mean error. This is because σ_{int} is based on a large number of degrees of freedom (the number of measured lines) while σ_{ext} has only a few degrees of freedom (the number of spectra for a given region.) For this reason, we have based mean-error estimates on σ_{int} in the past. We find that the average temperature at the equator is slightly higher than temperature of the polar regions (and the average temperature over the planet). Since the temperatures found for regions of Venus where the slit was aligned parallel to the equator are slightly warmer than the temperatures found when the slit was aligned from pole-to-pole, this might suggest that the average temperature distribution over the planet consists of three warm zones (N. polar, equatorial and S. polar) separated by 2 cooler zones. The evidence for such a suggestion

is rather weak, as can be seen from Table 6. The best data to compare with our present results are those of Young et al. (1971) for the 7820Å band and those of Schorn et al. (1974) for the 8689Å band; the other spectra were taken at lower dispersion, but are included in this comparison. With the exception of the present results and those of Young et al. (1969), the number of measurements (indicated in parentheses in Table 6) was usually much greater for the pole-to-pole observations than for those made with the slit aligned parallel to the equator. The temperature differences, weighted inversely by the error squared, indicate the average temperature in the equatorial and polar regions is 2.3°K higher than that near the limb or terminator.

From Table 5 we also find that greater than average amounts of CO₂ are found above the terminator and the north and south polar region; less than average amounts are found above the limb, equatorial and standard slit positions. Thus we do not find a correlation between higher than average amounts of CO₂ and higher than average rotational temperatures (as one would expect for almost any ordinary model atmosphere). If we ignore the limb and terminator results, because of the comparatively small number of measurements at these locations, the situation is not improved: A higher than average temperature (equatorial) region has a lower than average CO₂ abundance, but so does a lower than average temperature (standard slit position) region. Once again, we find no obvious relation between CO₂ abundance and temperature from our measurements of Venus.

Figure 18 shows the relation between the intercept of the linear least squares fits to the temperature, $W_o(0.5)$ and $W_o(b)$, and the CO₂ absorption ratio relative to the solar lines R. We see that $W_o(0.5)$ is probably a better measure of the CO₂ abundance than $W_o(b)$ since the former quantity shows less scatter as a function of R. Figure 19 shows the values of T as a function of the W_o . Since T(b) is believed to be the actual value of the rotational temperature and $W_o(0.5)$ the best measure of CO₂ abundance, this quantity is also shown. Once again, no relation between temperature and CO₂ abundance is obvious.

In Table 7 we give the differences $\Delta W_o(0.5) = (W_o(0.5)_i - \bar{W}_o(0.5)_i)$ and $\Delta T(b) = (T(b)_i - \bar{T}(b)_i)$, where i refers to the region on Venus; these are shown as a function of date in Figure 20. While there was no obvious correlation between temperatures and CO_2 abundances, it appears that these differences are correlated in the sense that positive values of ΔW correspond to negative values of ΔT . That is to say that $\frac{dT}{dW} < 0$ (or $\frac{dT}{dP} < 0$, since W is related to the abundance and hence the pressure, since CO_2 is a major, uniformly mixed constituent of the Venus atmosphere). This result implies that the region of the atmosphere we are observing is stable; since the warmer layers of the atmosphere are presumably at higher altitudes no convection is expected. Yet we observe quite considerable temporal variations in the temperature and, to a somewhat lesser extent, variations in the CO_2 abundance.

IV. Conclusions

We appear to be seeing real temperature variations in the atmosphere of Venus, as well as indications that the CO_2 abundance above the cloud tops (or optical depth $\tau \sim 1$) varies. The values of these two quantities do not appear to be related; however, the derivatives of these quantities with respect to time, $\frac{dT}{dt}$ and $\frac{dW}{dt}$ appear to be related by $\frac{dT}{dt} = -C \frac{dW}{dt}$, where C is presumably a constant. The average temperature ($249 \pm 1.4^\circ K$) found for this set of observations appears to be somewhat higher than the average temperature ($242 \pm 2^\circ K$) found in the past (Young, 1972) for series of observations extending over a longer time period. It will be of some interest to compare our results with those obtained at McDonald Observatory during the same time period, when the latter become available.

IV. Acknowledgement

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Figure 1-16 Height of Venus CO_2 lines, measured from density tracings of Venus spectra as a function of the rotational line index. The measurements of different individuals are indicated by different symbols as shown on the figure.

Figure 17 Histogram of rotational temperatures found from a curve of growth analysis of the data shown in Figures 1 to 16.

Figure 18 The relation between CO_2 abundance indicators $W_o(0.5)$ and $W_o(b)$ and the CO_2 abundance indicator R (the ratio of the sum of the heights of the CO_2 lines to the sum of the heights of the CO_2 lines to the sum of the heights of the solar calibration lines listed in Table 2).

Figure 19 Rotational temperature as a function of carbon dioxide abundance. The quantities $T(b)$, $W(b)$, and $T(0.5)$, $W_o(0.5)$ use the left hand and bottom scales; $T(b)$ and $W_o(0.5)$ use the right hand and top scales.

Figure 20 The quantities $\Delta W_o(0.5)$ and $\Delta T(b)$ for the dates of our 1972 observations.

Table I.
Spectrograms Studied

Plate	Date	Time of obser- vation U. T.	Slit Orientation	Seeing Sec. of arc	Z_{h_0} , Height of solar lines, mm	R, Ratio of CO ₂ to solar lines
T622	17 IX 72	13:06-13:36	6	1-3	228.7	2.04
T624a	17 IX 72	17:15-17:50	1	2-6	208.0	2.13
T624b	17 IX 72	17:52-18:27	2	2-6	208.3	2.00
T625a	18 IX 72	12:56-13:26	6	3-6	244.7	2.09
T625b	18 IX 72	14:06-14:36	3	3-6	219.0	2.15
T625c	18 IX 72	14:38-15:08	5	3-6	237.7	2.18
T627a	19 IX 72	14:58-14:28	6	4-10	414.7	1.97
T630a	20 IX 72	14:51-15:21	6	1-2	263.0	1.96
T630b	20 IX 72	15:26-15:56	5	1-2	220.0	1.89
T630c	20 IX 72	15:58-16:33	5	1-2	170.0	2.17
T631a	20 IX 72	16:45-17:05	4	2-3	242.0	1.89
T631b	20 IX 72	17:05-17:35	3	2-3	250.3	2.01
T633a	21 IX 72	14:52-15:22	6	2-3	253.7	2.07
T633b	21 IX 72	15:45-16:15	4	2-3	258.7	1.98
T636a	23 IX 72	14:20-15:10	6	2-4	295.0	1.94
T636b	23 IX 72	15:16-16:08	3	1-3	276.7	2.03
T636c	23 IX 72	16:11-17:01	5	5-7	284.7	1.93
T640a	25 IX 72	14:31-15:01	6	2-4	254.3	2.15
T640b	25 IX 72	15:06-15:36	4	2-6	245.0	2.08
T640c	25 IX 72	15:40-16:10	3	4-8	262.7	2.04
T641a	25 IX 72	16:34-17:04	3	3-10	255.7	1.94
T641b	25 IX 72	17:27-17:57	3	3-10	253.7	1.96
T641c	25 IX 72	18:16-18:41	2	6-10	221.0	1.99
T644a	26 IX 72	14:19-15:09	6	2-4	279.7	1.97
T644b	26 IX 72	15:12-15:52	2	3-6	262.0	1.92
T644c	26 IX 72	15:55-17:15	1	4-6	172.7	2.01
T645a	26 IX 72	17:41-18:11	4	4-6	251.3	2.07
T645b	26 IX 72	18:28-18:58	5	5-10	179.3	2.04
T645c	26 IX 72	19:01-19:31	3	3-15	177.0	2.09
T647b	27 IX 72	15:01-15:31	4	1-3	240.3	1.86
T647c	27 IX 72	15:34-16:04	4	2-5	271.0	1.89
T648a	27 IX 72	16:10-16:40	3	2-5	216.0	1.97
T648b	27 IX 72	16:44-17:14	6	1-6	227.0	1.93
T649b	28 IX 72	18:21-18:59	6	5-20	243.0	1.91
T650b	30 IX 72	13:09-13:49	6	1-2	261.7	2.12

<u>Plate</u>	<u>Date</u>	<u>Time of obser- vation U. T.</u>	<u>Slit Orientation</u>	<u>Seeing Sec. of arc</u>	<u>Height of solar lines, mm</u>	<u>Ratio of CO₂ to solar lines</u>
T650c	30 IX 72	13:52-14:22	4	1-2	239.0	2.13
T651a	30 IX 72	14:32-15:02	5	2	253.7	2.11
T651b	30 IX 72	15:05-15:35	3	2-5	225.0	2.16
T651c	30 IX 72	15:40-16:05	6	3-6	255.0	2.11
T654b	I X 72	16:53-17:23	6	2-7	269.0	1.84
T655b	2 X 72	13:17-13:52	6	10-20	263.7	1.91
T657b	3 X 72	13:46-15:27	6	3-10	266.3	1.99
T658b	4 X 72	13:27-14:08	6	5-10	240.3	2.07
T660b	5 X 72	12:56-13:27	6	1-2	268.0	1.98
T660c	5 X 72	13:33-14:03	4	1-3	226.7	1.86
T661b	7 X 72	14:17-14:56	6	1-3	251.0	1.93
T661c	7 X 72	15:03-15:31	4	1-3	217.7	2.11

Table 2
Solar Lines used for Intensity Calibration

Wavelength, Å	Equivalent Width, mÅ		ΔW, percent
	MMH*	BP**	
7800.000	61	----	----
7802.51	12	----	----
7807.916	64	----	----
7835.317	42	43.8	4.1
7836.130	64	65.6	2.4
7849.984	66	54.9	-20.2
7855.405	25	29.9	16.4
7861.045	12	14.0	14.3
7863.799	15	----	----
7896.378	28	----	----
7912.870	40	----	----

* Moore et al. (1966)

** Barker and Perry (1974)

Table 3

Results of Analysis of the 1972 data for the 7820A
Band of Carbon Dioxide, assuming
a constant CO₂ line width

Plate Number	Square Root Absorption Law				Curve of Growth Absorption Law			
	T(0.5) °K	W (0.5) mÅ	σ_{ϕ}^+ Percent	b	T(b) °K	W ₀ (b) mÅ	σ_{ϕ}^+ Percent	T ₀ °K
T622 G	212 ²²⁰ ₂₄₀	11.8	2.4	0.666	230 ²³⁶ ₂₂₅	8.5	1.8	240
Y	212 ²²¹ ₂₀₄	11.6	2.5	0.681	237 ²⁴² ₂₃₂	8.0	1.7	"
W	220 ²³⁴ ₂₀₇	11.0	3.6	0.718	238 ²⁴³ ₂₃₃	7.5	1.6	"
average	214 ²¹⁹ ₂₁₀	11.3	1.2	0.677	236 ²³⁸ ₂₃₃	8.0	0.9	240
T624a G	213 ²²³ ₂₀₄	12.1	2.7	0.640	238 ²⁴⁶ ₂₃₁	9.1	2.1	240
Y	225 ²³⁵ ₂₁₅	11.5	2.6	0.605	240 ²⁴⁸ ₂₃₃	9.3	2.1	"
W	229 ²⁴¹ ₂₁₉	11.7	2.8	0.582	243 ²⁵² ₂₃₅	9.8	2.2	"
average	222 ²²⁸ ₂₁₆	11.8	1.5	0.606	241 ²⁴⁵ ₂₃₆	9.5	1.2	240
T624b G	208 ²²⁴ ₁₉₄	11.2	4.5	0.746	233 ²⁴¹ ₂₂₇	7.1	2.5	240
Y	218 ²⁴⁰ ₂₀₀	10.7	5.6	0.792	246 ²⁵³ ₂₃₉	6.1	2.5	"
W	202 ²¹⁷ ₁₈₉	11.2	4.5	0.773	232 ²³⁸ ₂₂₅	6.6	2.6	"
average	209 ²¹⁹ ₂₀₁	11.0	2.8	0.779	238 ²⁴² ₂₃₄	6.5	1.5	240

Table 3 - Cont.
Page 2

Plate Number		T(0.5) °K	W ₀ (0.5) mÅ	σ_{ϕ} Percent	b	T(b) °K	W ₀ (b) mÅ	σ_{ϕ} Percent	T ₀ °K
T625a	G	253 ²⁷³ ₂₃₇	10.9	3.7	0.682	262 ²⁶⁸ ₂₅₅	7.9	1.8	260
	Y	238 ²⁵⁴ ₂₂₄	11.0	3.6	0.760	265 ²⁷⁰ ₂₆₀	6.4	1.5	"
	W	238 ²⁵⁴ ₂₂₄	11.3	3.5	0.738	265 ²⁷¹ ₂₅₉	7.0	1.7	"
	average	243 ²⁵² ₂₃₄	11.1	2.1	0.714	263 ²⁶⁷ ₂₅₉	7.2	1.0	260
T625b	G	230 ²⁴³ ₂₁₈	11.7	3.1	0.646	244 ²⁵⁰ ₂₃₈	8.8	1.7	240
	Y	218 ²³¹ ₂₀₆	11.4	3.6	0.679	238 ²⁴⁵ ₂₃₂	8.1	2.2	"
	W	235 ²⁵¹ ₂₂₁	11.1	3.5	0.649	249 ²⁵⁷ ₂₄₂	8.4	2.2	"
	average	227 ²³⁵ ₂₂₀	11.5	2.0	0.655	243 ²⁴⁷ ₂₃₉	8.5	1.2	240
T625c	G	220 ²³³ ₂₀₈	12.4	3.3	0.690	237 ²⁴² ₂₃₁	8.7	1.8	240
	Y	225 ²³⁹ ₂₁₃	11.7	3.5	0.691	244 ²⁴⁸ ₂₃₉	8.1	1.5	"
	W	223 ²³³ ₂₁₃	11.9	2.8	0.640	237 ²⁴² ₂₃₂	9.1	1.6	"
	average	222 ²²⁹ ₂₁₆	12.0	1.8	0.678	239 ²⁴³ ₂₃₆	8.6	1.0	240
T627a	G	216 ²²⁹ ₂₀₄	11.1	3.5	0.681	229 ²³⁵ ₂₂₃	8.0	1.9	240
	Y	211 ²²⁵ ₁₉₉	10.8	3.8	0.719	228 ²³³ ₂₂₂	7.3	1.8	"
	W	226 ²⁴¹ ₂₁₂	10.6	3.8	0.703	244 ²⁵⁰ ₂₃₈	7.2	1.7	"

Table 3 - Cont.
Page 3

Plate Number	T(0.5) °K	W _o (0.5) mA	σ_{ϕ} Percent	b	T(b) °K	W _o (b) mA	σ_{ϕ} Percent	T _o °K
G	218 ²³¹ ₂₀₆	10.9	3.6	0.694	232 ²³⁶ ₂₂₈	7.6	1.5	240
W	225 ²³⁹ ₂₁₂	10.1	3.5	0.693	239 ²⁴⁴ ₂₃₃	7.0	1.6	"
average	219 ²²⁵ ₂₁₃	10.8	1.6	0.703	235 ²³⁷ ₂₃₂	7.4	0.8%	240
T630a G	231 ²⁴⁴ ₂₁₉	10.6	3.1	0.656	246 ²⁵² ₂₄₀	8.0	1.7	240
Y	220 ²³⁶ ₂₀₆	10.6	4.1	0.724	243 ²⁴⁹ ₂₃₈	6.9	1.8	"
W	230 ²⁴² ₂₁₉	10.4	4.0	0.679	246 ²⁵³ ₂₄₀	7.4	2.1	"
average	227 ²³⁵ ₂₁₉	10.5	2.1	0.678	243 ²⁴⁶ ₂₃₉	7.5	1.1	240
T630b G	248 ²⁶¹ ₂₃₆	10.4	2.8	0.601	268 ²⁷⁷ ₂₆₀	5.1	2.0	260
Y	226 ²⁴⁸ ₂₀₈	9.5	5.1	0.898	270 ²⁷⁶ ₂₆₄	4.3	1.9	"
W	238 ²⁶⁰ ₂₁₈	9.5	4.9	0.766	261 ²⁶⁸ ₂₅₄	5.8	2.2	"
average	238 ²⁵⁰ ₂₂₇	9.8	2.7	0.780	266 ²⁷² ₂₆₁	5.7	1.5	260
T630c G	227 ²³⁸ ₂₁₈	12.9	2.6	0.544	252 ²⁶⁰ ₂₄₄	11.8	1.7	250
Y	223 ²³⁵ ₂₁₁	12.2	3.2	0.621	253 ²⁶³ ₂₄₄	9.3	2.1	"
W	228 ²³⁸ ₂₁₈	12.3	2.6	0.512	249 ²⁵⁹ ₂₄₀	12.0	1.9	"
average	226 ²³² ₂₂₀	12.5	1.6	0.551	248 ²⁵⁴ ₂₄₃	11.2	1.2	250

Table 3 - Cont.
Page 4

Plate Number		T(0.5) °K	W _o (0.5) mA	σ_o + Percent	b	T(b) °K	W _o (b) mA	σ_o + Percent	T _o °K
T631a	G	236 ²⁴⁶ ₂₂₆	10.4	2.3	0.691	260 ²⁶⁵ ₂₅₆	7.0	1.3	260
	Y	221 ²³³ ₂₀₉	10.3	3.3	0.786	257 ²⁶³ ₂₅₁	5.7	1.8	"
	W	225 ²³⁷ ₂₁₄	10.2	3.1	0.760	259 ²⁶⁵ ₂₅₃	6.0	1.7	"
	average	227 ²³⁴ ₂₂₁	10.3	1.7	0.733	260 ²⁶³ ₂₅₆	6.4	1.0	260
T631b	G	237 ²⁴⁸ ₂₂₇	11.0	2.4	0.514	233 ²⁴¹ ₂₂₆	11.0	2.0	240
	Y	239 ²⁵² ₂₂₈	10.6	2.9	0.605	252 ²⁵⁹ ₂₄₅	8.6	1.8	"
	W	248 ²⁵⁹ ₂₃₇	10.6	2.4	0.517	246 ²⁵⁴ ₂₃₈	10.5	1.8	"
	average	241 ²⁴⁸ ₂₃₅	10.7	1.5	0.535	243 ²⁴⁸ ₂₃₈	10.2	1.2	240
T633a	G	233 ²⁴¹ ₂₂₆	11.2	1.9	0.626	246 ²⁵¹ ₂₄₂	8.9	1.1	250
	Y	236 ²⁴⁸ ₂₂₆	11.0	2.7	0.652	249 ²⁵⁵ ₂₄₃	8.1	1.5	"
	W	216 ²²⁵ ₂₀₇	11.2	2.6	0.716	238 ²⁴³ ₂₃₃	7.4	1.6	"
	average	228 ²³⁴ ₂₂₃	11.2	1.4	0.658	245 ²⁴⁸ ₂₄₂	8.3	0.8	250
T633b	G	241 ²⁴⁹ ₂₃₃	11.2	1.8	0.590	254 ²⁵⁹ ₂₄₉	9.3	1.3	250
	Y	227 ²³⁶ ₂₂₀	11.0	2.0	0.663	250 ²⁵⁵ ₂₄₆	7.9	1.2	"
	W	213 ²²² ₂₀₆	11.5	2.3	0.680	244 ²⁴⁹ ₂₃₉	7.7	1.5	"
	G	224 ²³³ ₂₁₆	11.2	2.2	0.658	251 ²⁵⁶ ₂₄₅	8.0	1.5	"
	W	223 ²³² ₂₁₄	10.5	2.3	0.689	248 ²⁵³ ₂₄₃	7.2	1.5	"

Table 3 - Cont.

Page 5

Plate Number	T(0.5) °K	W ₀ (0.5) mA	σ_{ϕ} Percent	b	T(b) °K	W ₀ (b) mA	σ_{ϕ} Percent	T ₀ °K
average	225 ²²⁹ ₂₂₂	11.0	1.0	0.661	248 ²⁵⁰ ₂₄₆	8.0	0.6	250
T636a G	249 ²⁶² ₂₃₈	10.3	2.6	0.657	268 ²⁷⁴ ₂₆₂	7.6	1.5	260
Y	238 ²⁵² ₂₂₆	10.3	3.2	0.714	266 ²⁷¹ ₂₆₁	6.6	1.5	"
W	242 ²⁵⁷ ₂₂₈	10.5	2.9	0.717	260 ²⁶⁶ ₂₅₄	6.8	1.5	"
average	238 ²⁴⁵ ₂₃₂	10.5	1.6	0.704	264 ²⁶⁷ ₂₆₀	6.9	0.9	260
T636b G	226 ²³⁵ ₂₁₉	10.9	2.1	0.680	247 ²⁵² ₂₄₃	7.6	1.3	250
Y	238 ²⁴⁸ ₂₂₈	10.3	2.3	0.673	256 ²⁶¹ ₂₅₂	7.3	1.4	"
W	223 ²³¹ ₂₁₅	10.7	2.1	0.690	247 ²⁵¹ ₂₄₃	7.2	1.3	"
average	229 ²³⁴ ₂₂₄	10.7	1.2	0.682	250 ²⁵³ ₂₄₈	7.3	0.8	250
T636c G	233 ²⁴³ ₂₂₃	10.6	2.4	0.667	249 ²⁵³ ₂₄₆	7.7	1.1	250
Y	219 ²²⁷ ₂₁₁	10.5	2.2	0.727	246 ²⁵¹ ₂₄₂	6.7	1.3	"
W	216 ²²⁴ ₂₀₈	10.5	2.2	0.731	246 ²⁴⁹ ₂₄₂	6.6	1.1	"
average	222 ²²⁷ ₂₁₈	10.5	1.3	0.714	248 ²⁵⁰ ₂₄₅	6.9	0.7	250

Table 3 - Cont.
Page 6

Plate Number		T(0.5) °K	W _o (0.5) mA	σ_{ϕ} Percent	b	T(b) °K	W _o (b) mA	σ_{ϕ} Percent	T _o °K
T640a	G	226 ²³⁶ ₂₁₇	12.0	2.4	0.628	237 ²⁴¹ ₂₃₂	9.5	1.4	240
	Y	223 ²³⁵ ₂₁₂	11.6	3.0	0.660	238 ²⁴² ₂₃₃	8.6	1.4	"
	W	223 ²³⁵ ₂₁₂	11.6	3.1	0.672	239 ²⁴⁴ ₂₃₄	8.4	1.4	"
average		224 ²³⁰ ₂₁₈	11.7	1.6	0.659	239 ²⁴² ₂₃₆	8.8	0.8	240
T640b	G	247 ²⁶² ₂₃₄	11.1	3.0	0.651	262 ²⁷¹ ₂₅₄	8.3	2.2	260
	Y	243 ²⁵⁶ ₂₃₀	10.8	2.9	0.657	258 ²⁶⁶ ₂₅₁	8.0	2.1	"
	W	247 ²⁶² ₂₃₃	10.7	3.2	0.667	261 ²⁶⁹ ₂₅₄	7.8	2.1	"
	G	253 ²⁷⁴ ₂₃₅	10.8	4.2	0.644	260 ²⁷³ ₂₄₈	8.3	3.3	"
	Y	245 ²⁶⁰ ₂₄₁	10.8	3.2	0.661	259 ²⁶⁶ ₂₅₁	7.9	2.2	"
	W	252 ²⁷⁰ ₂₃₇	10.2	3.6	0.633	266 ²⁷⁶ ₂₅₆	7.9	2.5	"
average		248 ²⁵⁴ ₂₄₂	10.8	1.4	0.652	260 ²⁶⁴ ₂₅₇	8.0	0.9	260
T640c	G	243 ²⁶⁶ ₂₂₄	11.0	4.1	0.718	256 ²⁶¹ ₂₅₁	7.1	1.5	260
	Y	241 ²⁵³ ₂₃₀	10.7	2.8	0.686	269 ²⁷⁴ ₂₆₃	7.1	1.4	"
	W	239 ²⁵⁷ ₂₂₄	10.9	3.4	0.725	268 ²⁷⁴ ₂₆₂	6.6	1.6	"
average		240 ²⁵⁰ ₂₃₁	10.9	2.0	0.709	264 ²⁶⁷ ₂₆₁	7.0	0.9	260

Table 3 - Cont.
Page 7

Plate Number		T(0.5) °K	W ₀ (0.5) mA	σ_{ϕ} Percent	b	T(b) °K	W ₀ (b) mA	σ_{ϕ} Percent	T ₀ °K
T641a	G	256 ²⁷¹ ₂₄₂	10.3	3.0	0.586	266 ²⁷⁶ ₂₅₆	8.7	2.1	260
	Y	241 ²⁵⁸ ₂₂₆	10.0	3.5	0.669	253 ²⁶¹ ₂₄₆	7.2	2.0	"
	W	249 ²⁶⁸ ₂₃₃	9.9	3.7	0.657	262 ²⁷¹ ₂₅₃	7.3	2.2	"
average		249 ²⁵⁸ ₂₄₀	10.0	2.0	0.647	260 ²⁶⁵ ₂₅₅	7.6	1.3	260
T641b	G	249 ²⁶² ₂₃₇	10.6	2.7	0.601	259 ²⁶⁸ ₂₅₀	8.8	2.1	260
	Y	247 ²⁶² ₂₃₃	10.1	3.2	0.660	260 ²⁶⁸ ₂₅₃	7.5	1.9	"
	W	249 ²⁶² ₂₃₈	10.3	2.6	0.585	261 ²⁷⁰ ₂₅₃	8.7	2.0	"
average		248 ²⁵⁶ ₂₄₁	10.3	1.7	0.618	261 ²⁶⁶ ₂₅₆	8.3	1.2	260
T641c	G	224 ²³⁵ ₂₁₃	11.1	2.9	0.609	237 ²⁴⁵ ₂₃₀	8.9	2.1	240
	Y	217 ²³⁰ ₂₀₆	10.4	3.4	0.682	241 ²⁴⁸ ₂₃₄	7.3	2.2	"
	W	224 ²³⁸ ₂₁₂	10.4	3.4	0.643	245 ²⁵³ ₂₃₇	7.9	2.3	"
average		222 ²²⁹ ₂₁₅	10.7	1.9	0.644	241 ²⁴⁶ ₂₃₇	8.0	1.4	240
T644a	G	200 ²¹³ ₁₈₈	11.3	4.2	0.807	244 ²⁵⁰ ₂₃₈	5.9	1.9	240
	Y	212 ²²⁹ ₁₉₇	10.8	4.6	0.737	240 ²⁴⁶ ₂₃₄	6.8	1.8	"
	W	210 ²²⁶ ₁₉₅	10.8	4.7	0.752	238 ²⁴⁴ ₂₃₃	6.6	1.8	"
average		207 ²¹⁶ ₁₉₉	10.9	2.6	0.756	239 ²⁴³ ₂₃₆	6.6	1.0	240

Table 3 - Cont.

Page 8

Plate Number		T(0.5) °K	W ₀ (0.5) mA	σ_{ϕ} Percent	b	T(b) °K	W ₀ (b) mA	σ_{ϕ} Percent	T ₀ °K
T644b	G	218 ²²⁹ ₂₀₉	10.9	2.8	0.637	235 ²⁴² ₂₂₈	8.3	2.2	240
	Y	226 ²³⁹ ₂₁₄	10.4	3.3	0.667	245 ²⁵² ₂₃₈	7.5	2.2	"
	W	223 ²³⁶ ₂₁₁	10.3	3.4	0.673	244 ²⁵² ₂₃₇	7.4	2.3	"
average		222 ²²⁹ ₂₁₆	10.5	1.8	0.660	242 ²⁴⁶ ₂₃₇	7.6	1.3	240
T644c	G	230 ²³⁷ ₂₂₄	11.0	1.6	0.623	249 ²⁵² ₂₄₅	8.5	0.9	250
	Y	236 ²⁴⁶ ₂₂₇	10.4	2.2	0.669	251 ²⁵⁴ ₂₄₇	7.6	1.1	"
	W	224 ²³⁴ ₂₁₅	10.6	2.4	0.688	244 ²⁴⁸ ₂₄₁	7.4	0.9	"
average		230 ²³⁵ ₂₂₅	10.8	1.2	0.674	248 ²⁵¹ ₂₄₆	7.6	0.6	250
T645a	G	242 ²⁵⁰ ₂₃₃	11.4	1.9	0.635	257 ²⁶² ₂₅₂	8.6	1.3	260
	Y	242 ²⁵³ ₂₃₃	11.1	2.3	0.645	261 ²⁶⁷ ₂₅₆	8.2	1.4	"
	W	236 ²⁴⁷ ₂₂₇	11.0	2.5	0.666	255 ²⁶¹ ₂₄₉	7.8	1.6	"
average		240 ²⁴⁶ ₂₃₄	11.1	1.3	0.646	257 ²⁶¹ ₂₅₄	8.4	0.9	260
T645b	G	223 ²²⁹ ₂₁₇	11.5	1.6	0.531	230 ²³⁵ ₂₂₅	10.8	1.2	230
	Y	197 ²⁰⁴ ₁₉₁	11.3	2.2	0.641	227 ²³² ₂₂₃	8.4	1.4	"
	W	208 ²¹⁵ ₂₀₃	11.3	1.9	0.612	228 ²³² ₂₂₃	9.0	1.2	"
average		209 ²¹³ ₂₀₅	11.5	1.2	0.595	226 ²²⁹ ₂₂₃	9.3	0.8	230

Table 3 - Cont.
Page 9

Plate Number		T(0.5) °K	W ₀ (0.5) mA	σ_{ϕ} Percent	b	T(b) °K	W ₀ (b) mA	σ_{ϕ} Percent	T ₀ °K
T645c	G	252 ²⁶³ ₂₄₂	11.1	2.2	0.555	255 ²⁶² ₂₄₈	10.0	1.7	240
	Y	229 ²³⁹ ₂₁₉	11.3	2.5	0.625	245 ²⁵¹ ₂₃₉	8.9	1.8	"
	W	220 ²²⁹ ₂₁₂	11.3	2.3	0.650	240 ²⁴⁷ ₂₃₅	8.3	1.7	"
average		233 ²³⁹ ₂₂₈	11.3	1.4	0.597	245 ²⁴⁹ ₂₄₁	9.3	1.0	240
T647b	G	234 ²⁴⁹ ₂₂₀	9.8	3.7	0.691	256 ²⁶⁸ ₂₄₅	6.7	2.9	260
	Y	235 ²⁴⁸ ₂₂₃	10.6	3.1	0.687	253 ²⁶¹ ₂₄₅	7.2	2.2	"
	W	242 ²⁵⁸ ₂₂₈	9.7	3.4	0.691	258 ²⁶⁹ ₂₄₇	6.6	2.5	"
average		237 ²⁴⁶ ₂₂₉	10.0	2.0	0.689	257 ²⁶³ ₂₅₁	6.8	1.5	260
T647c	G	233 ²⁴² ₂₂₅	10.4	2.2	0.649	255 ²⁶⁰ ₂₅₀	7.6	1.3	250
	Y	224 ²³⁵ ₂₁₄	10.2	2.8	0.736	251 ²⁵⁶ ₂₄₇	6.3	1.4	"
	W	216 ²²⁶ ₂₀₇	10.2	2.7	0.684	244 ²⁴⁹ ₂₃₈	7.0	1.5	"
average		224 ²³⁰ ₂₁₉	10.3	1.5	0.691	252 ²⁵⁵ ₂₄₉	6.9	0.8	250
T648a	G	238 ²⁴⁵ ₂₃₂	10.8	1.4	0.578	247 ²⁵⁰ ₂₄₄	9.3	0.9	250
	Y	238 ²⁴⁶ ₂₃₁	10.5	1.7	0.622	253 ²⁵⁷ ₂₄₉	8.2	1.1	"
	W	238 ²⁴⁷ ₂₃₀	10.3	2.0	0.635	252 ²⁵⁶ ₂₄₉	7.9	1.0	"
average		238 ²⁴³ ₂₃₄	10.5	1.0	0.603	250 ²⁵² ₂₄₇	8.7	0.7	250

Table 3 - Cont.
Page 10

Plate Number		T(0.5) °K	W _o (0.5) mA	σ_{ϕ} Percent	b	T(b) °K	W _o (b) mA	σ_{ϕ} Percent	T _o °K
T648b	G	242 ²⁵¹ ₂₃₃	10.3	2.0	0.640	253 ²⁵⁷ ₂₄₉	7.8	1.0	250
	Y	233 ²⁴² ₂₂₄	10.1	2.2	0.664	248 ²⁵¹ ₂₄₆	7.4	0.7	"
	W	222 ²³² ₂₁₄	10.4	2.4	0.695	241 ²⁴⁴ ₂₃₈	7.1	0.9	"
	average	232 ²³⁷ ₂₂₇	10.3	1.3	0.668	248 ²⁵⁰ ₂₄₆	7.4	0.5	250
T649b	G	218 ²³⁵ ₂₀₃	10.8	4.4	0.735	241 ²⁴⁶ ₂₃₆	6.9	1.7	240
	Y	209 ²²⁸ ₁₉₃	10.1	5.2	0.832	234 ²³⁹ ₂₂₉	5.4	1.9	"
	W	203 ²¹⁶ ₁₉₁	10.5	4.1	0.789	236 ²⁴² ₂₃₀	5.9	2.2	"
	average	210 ²¹⁹ ₂₀₁	10.5	2.7	0.778	237 ²⁴⁰ ₂₃₃	6.1	1.2	240
T650b	G	232 ²⁴² ₂₂₃	11.0	2.3	0.669	248 ²⁵² ₂₄₄	8.1	1.3	250
	Y	229 ²³⁶ ₂₂₃	11.5	1.7	0.648	249 ²⁵² ₂₄₅	8.5	1.1	"
	W	226 ²³⁵ ₂₁₈	11.2	2.3	0.680	244 ²⁴⁷ ₂₄₁	7.9	1.0	"
	average	229 ²³⁴ ₂₂₅	11.3	1.2	0.669	247 ²⁵⁰ ₂₄₅	8.1	0.6	250
T650c	G	244 ²⁵³ ₂₃₅	11.8	2.0	0.668	251 ²⁵⁶ ₂₄₆	8.5	1.2	250
	Y	228 ²³⁷ ₂₂₀	11.5	2.2	0.707	247 ²⁵¹ ₂₄₂	7.5	1.1	"
	W	236 ²⁴⁶ ₂₂₇	11.4	2.3	0.725	246 ²⁵¹ ₂₄₂	7.3	1.2	"
	average	236 ²⁴¹ ₂₃₁	11.5	1.3	0.687	249 ²⁵² ₂₄₆	8.0	0.7	250

Table 3 - Cont.
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Plate Number		T(0.5) °K	W _O (0.5) mÅ	σ_{ϕ} Percent	b	T(b) °K	W _O (b) mÅ	σ_{ϕ} Percent	T _O °K
T651a	G	234 ²⁴⁹ ₂₂₀	11.5	3.7	0.707	259 ²⁶⁴ ₂₅₄	7.6	1.3	260
	Y	238 ²⁵⁵ ₂₂₄	11.1	3.6	0.780	269 ²⁷⁴ ₂₆₄	6.2	1.3	"
	W	236 ²⁵² ₂₃₁	11.1	3.7	0.754	261 ²⁶⁶ ₂₅₅	6.7	1.6	"
average		236 ²⁴⁵ ₂₂₈	11.2	2.1	0.749	262 ²⁶⁴ ₂₅₉	6.9	0.9	260
T651b	G	232 ²⁴² ₂₂₂	11.7	2.5	0.640	247 ²⁵³ ₂₄₂	8.9	1.6	250
	Y	229 ²³⁹ ₂₂₁	11.5	2.2	0.653	253 ²⁵⁷ ₂₄₈	8.3	1.4	"
	W	237 ²⁴⁸ ₂₂₆	11.5	2.6	0.665	258 ²⁶⁴ ₂₅₃	8.0	1.5	"
average		233 ²³⁸ ₂₂₇	11.5	1.4	0.649	251 ²⁵⁵ ₂₄₈	8.5	0.9	250
T651c	G	237 ²⁴⁶ ₂₂₈	11.4	2.2	0.542	244 ²⁵¹ ₂₃₇	10.4	1.7	240
	Y	235 ²⁴⁵ ₂₂₆	11.3	2.3	0.583	245 ²⁵² ₂₃₈	9.5	1.7	"
	W	233 ²⁴³ ₂₂₄	11.4	2.3	0.579	242 ²⁴⁹ ₂₃₆	9.6	1.8	"
average		235 ²⁴⁰ ₂₃₀	11.4	1.3	0.566	244 ²⁴⁸ ₂₄₀	9.9	1.0	240
T654b	G	238 ²⁵¹ ₂₂₇	9.8	2.7	0.651	255 ²⁶² ₂₄₉	7.2	1.8	260
	Y	238 ²⁵² ₂₂₆	9.9	3.1	0.729	263 ²⁶⁹ ₂₅₇	6.2	1.5	"
	W	234 ²⁴⁸ ₂₂₁	9.8	3.3	0.690	252 ²⁵⁸ ₂₄₆	6.7	1.7	"
average		237 ²⁴⁴ ₂₃₀	9.8	1.7	0.692	258 ²⁶² ₂₅₅	6.7	1.0	260

Table 3 - Cont.

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Plate Number		T(0.5) °K	W _o (0.5) mA	σ_o + Percent	b	T(b) °K	W _o (b) mA	σ_o ± Percent	T _o °K
T655b	G	215 ²²⁶ ₂₀₆	10.6	2.8	0.705	238 ²⁴³ ₂₃₃	7.0	1.5	240
	Y	229 ²³⁹ ₂₂₀	10.4	2.5	0.629	244 ²⁵⁰ ₂₃₈	8.1	1.7	"
	W	233 ²⁴⁵ ₂₂₃	10.2	2.7	0.622	248 ²⁵⁵ ₂₄₁	8.0	1.9	"
average		226 ²³² ₂₂₀	10.3	1.5	0.648	244 ²⁴⁷ ₂₄₀	7.7	1.0	240
T657b	G	235 ²⁴⁵ ₂₂₅	10.7	2.5	0.688	250 ²⁵³ ₂₄₆	7.5	1.1	250
	Y	231 ²⁴² ₂₂₁	10.6	2.6	0.709	251 ²⁵⁵ ₂₄₇	7.0	1.1	"
	W	226 ²³⁶ ₂₁₇	10.7	2.5	0.702	241 ²⁴⁴ ₂₃₈	7.3	1.0	"
average		230 ²³⁶ ₂₂₅	10.7	1.4	0.695	247 ²⁴⁹ ₂₄₅	7.4	0.6	250
T658b	G	235 ²⁴⁶ ₂₂₄	11.3	2.5	0.684	257 ²⁶³ ₂₅₂	7.8	1.4	260
	Y	237 ²⁵⁰ ₂₂₅	11.1	2.9	0.712	260 ²⁶⁶ ₂₅₄	7.2	1.7	"
	W	232 ²⁴³ ₂₂₀	11.1	2.6	0.705	256 ²⁶² ₂₅₁	7.2	1.6	"
average		234 ²⁴¹ ₂₂₈	11.1	1.5	0.702	257 ²⁶⁰ ₂₅₄	7.4	0.9	260
T660b	G	226 ²³⁶ ₂₁₇	10.8	2.4	0.694	255 ²⁶¹ ₂₄₉	7.2	1.5	250
	Y	217 ²²⁶ ₂₀₉	10.9	2.3	0.694	248 ²⁵² ₂₄₃	7.3	1.2	"
	W	222 ²³⁰ ₂₁₄	10.8	2.1	0.705	249 ²⁵³ ₂₄₆	7.1	1.0	"
average		222 ²²⁷ ₂₁₇	10.9	1.3	0.699	251 ²⁵³ ₂₄₈	7.2	0.7	250

Table 3 - Cont.
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Plate Number		T(0.5) °K	W _o (0.5) mA	σ_{ϕ} Percent	b	T(b) °K	W _o (b) mA	σ_{ϕ} Percent	T _o °K
T660c	G	257 ²⁶⁷ ₂₄₈	9.8	2.0	0.488	257 ²⁶⁶ ₂₄₉	10.0	1.7	250
	Y	235 ²⁴⁴ ₂₂₇	9.7	2.0	0.610	248 ²⁵³ ₂₄₃	7.8	1.3	"
	W	234 ²⁴³ ₂₂₆	9.7	2.1	0.575	242 ²⁴⁸ ₂₃₇	8.2	1.6	"
	G	226 ²³³ ₂₁₈	10.6	1.9	0.526	231 ²³⁷ ₂₂₅	10.0	1.6	"
	Y	235 ²⁴³ ₂₂₇	9.7	1.9	0.577	241 ²⁴⁶ ₂₃₆	8.4	1.4	"
	W	238 ²⁴⁹ ₂₂₉	9.3	2.3	0.622	248 ²⁵⁴ ₂₄₂	7.4	1.5	"
average		237 ²⁴¹ ₂₃₃	9.8	0.9	0.574	245 ²⁴⁸ ₂₄₂	8.4	0.7	250
T661b	G	244 ²⁶² ₂₂₈	10.5	3.9	0.704	265 ²⁷⁴ ₂₅₈	6.9	2.1	260
	Y	238 ²⁵⁶ ₂₂₃	10.3	3.9	0.711	260 ²⁶⁷ ₂₅₄	6.8	1.9	"
	W	241 ²⁵⁹ ₂₂₆	10.5	3.9	0.720	262 ²⁶⁹ ₂₅₆	6.7	1.8	"
average		241 ²⁵¹ ₂₃₂	10.5	2.2	0.713	262 ²⁶⁶ ₂₅₈	6.8	1.1	260
T661c	G	227 ²³⁴ ₂₂₀	11.6	1.8	0.679	249 ²⁵² ₂₄₆	8.1	0.9	250
	Y	228 ²³⁶ ₂₂₁	11.5	2.0	0.688	249 ²⁵³ ₂₄₆	7.8	1.1	"
	W	218 ²²⁶ ₂₁₀	11.5	2.2	0.694	243 ²⁴⁷ ₂₃₉	7.7	1.2	"
average		224 ²²⁹ ₂₂₀	11.5	1.2	0.685	248 ²⁵⁰ ₂₄₆	7.8	0.6	250

Table 4
Temperatures found for different values of T_o .

$T_o, ^\circ K$	Measurer of Plate T660B								
	G	Y	W	G	Y	W	G	Y	W
	$T(b), ^\circ K$			Standard deviation			$\Delta T, ^\circ K$		
240	254	247	248	.0697	.0561	.0489	+14	+7	+8
250	255	248	249	.0663	.0540	.0465	+ 5	-2	-1
260	260	251	253	.0663	.0570	.0477	+0	-9	-7

Table 5
Summary of Table 3

Plate Number	Slit Position	Square Root Absorption Law			Curve of Growth Absorption Law			
		T(0.5) °K	W ₀ (0.5) mÅ	σ_p Percent	b	T(b) °K	W ₀ (b) mÅ	σ_p Percent
T622	Std	214 ²¹⁹ ₂₁₀	11.3	1.2	0.677	236 ²³⁸ ₂₃₃	8.0	0.9
T624a	T	222 ²²⁸ ₂₁₆	11.8	1.5	0.606	241 ²⁴⁵ ₂₃₆	9.5	1.2
T624b	L	209 ²¹⁹ ₂₀₁	11.0	2.8	0.779	238 ²⁴² ₂₃₄	6.5	1.5
T625a	Std	243 ²⁵² ₂₃₄	11.1	2.1	0.714	263 ²⁶⁷ ₂₅₉	7.2	1.0
T625b	S -28	227 ²³⁵ ₂₂₀	11.5	2.0	0.655	243 ²⁴⁷ ₂₃₉	8.5	1.2
T625c	N +27	222 ²²⁹ ₂₁₆	12.0	1.8	0.678	239 ²⁴³ ₂₃₆	8.6	1.0
T627a	Std	219 ²²⁵ ₂₁₃	10.8	1.6	0.703	235 ²³⁷ ₂₃₂	7.4	0.8
T630a	Std+18°	227 ²³⁵ ₂₁₉	10.5	2.1	0.678	243 ²⁴⁶ ₂₃₉	7.5	1.1
T630b	N +26	238 ²⁵⁰ ₂₂₇	9.8	2.7	0.780	266 ²⁷² ₂₆₁	5.7	1.5
T630c	NN +54	226 ²³² ₂₂₀	12.5	1.6	0.551	248 ²⁵⁴ ₂₄₃	11.2	1.2
T631a	Eq -9	227 ²³⁴ ₂₂₁	10.3	1.7	0.733	260 ²⁶³ ₂₅₆	6.4	1.0
T631b	S -17	241 ²⁴⁸ ₂₃₅	10.7	1.5	0.535	243 ²⁴⁸ ₂₃₈	10.2	1.2
T633a	Std+30	228 ²³⁴ ₂₂₃	11.2	1.4	0.658	245 ²⁴⁸ ₂₄₂	8.3	0.8
T633b	Eq -6	225 ²²⁹ ₂₂₂	11.0	1.0	0.661	248 ²⁵⁰ ₂₄₆	8.0	0.6
T636a	Std+28	238 ²⁴⁵ ₂₃₂	10.5	1.6	0.704	264 ²⁶⁷ ₂₆₀	6.9	0.9
T636b	S -24	229 ²³⁴ ₂₂₄	10.7	1.2	0.682	250 ²⁵⁸ ₂₄₈	7.3	0.8
T636c	N +15	222 ²²⁷ ₂₁₈	10.5	1.3	0.714	248 ²⁵⁰ ₂₄₅	6.9	0.7

Table 5 - Cont.

Page 2

Plate Number	Slit Position	T(0.5) °K	Wo(0.5) mA	σ_{ϕ} Percent	b	T(b) °K	Wo(b) mA	σ_{ϕ} Percent
T640a	Std+19	223 ²³⁵ ₂₁₂	11.7	1.6	0.659	239 ²⁴² ₂₃₆	8.8	0.8
T640b	Eq -2	248 ²⁵⁴ ₂₄₂	10.8	1.4	0.652	260 ²⁶⁴ ₂₅₇	8.0	0.9
T640c	S -33	240 ²⁵⁰ ₂₃₁	10.9	2.0	0.709	264 ²⁶⁷ ₂₆₁	7.0	0.9
T641a	Eq +8	249 ²⁵⁸ ₂₄₀	10.0	2.0	0.647	260 ²⁶⁵ ₂₅₅	7.6	1.3
T641b	Eq +10	248 ²⁵⁶ ₂₄₁	10.3	1.7	0.618	261 ²⁶⁶ ₂₅₆	8.3	1.2
T641c	L +50	222 ²²⁹ ₂₁₅	10.7	1.9	0.644	241 ²⁴⁶ ₂₃₇	8.0	1.4
T644a	Std+24	207 ²¹⁶ ₁₉₉	10.9	2.6	0.756	239 ²⁴³ ₂₃₆	6.6	1.0
T644b	L +47	222 ²²⁹ ₂₁₆	10.5	1.8	0.660	242 ²⁴⁶ ₂₃₇	7.6	1.3
T644c	T +0	230 ²³⁵ ₂₂₅	10.8	1.2	0.674	248 ²⁵¹ ₂₄₆	7.6	0.6
T645a	Eq -6	240 ²⁴⁶ ₂₃₄	11.1	1.3	0.646	257 ²⁶¹ ₂₅₄	8.4	0.9
T645b	N +42	209 ²¹³ ₂₀₅	11.5	1.2	0.595	226 ²²⁹ ₂₂₃	9.3	0.8
T645c	S -36	233 ²³⁹ ₂₂₈	11.3	1.4	0.597	245 ²⁴⁹ ₂₄₁	9.3	1.0
T647b	N +42	237 ²⁴⁶ ₂₂₉	10.0	2.0	0.689	257 ²⁶³ ₂₅₁	6.8	1.5
T647c	Eq -4	224 ²³⁰ ₂₁₉	10.3	1.5	0.691	252 ²⁵⁵ ₂₄₉	6.9	0.8
T648a	S -28	238 ²⁴³ ₂₃₄	10.5	1.0	0.603	250 ²⁵² ₂₄₇	8.7	0.7
T648b	Std+21	232 ²³⁷ ₂₂₇	10.3	1.3	0.668	248 ²⁵⁰ ₂₄₆	7.4	0.5
T649b	Std	210 ²¹⁹ ₂₀₁	10.5	2.7	0.778	237 ²⁴⁰ ₂₃₃	6.1	1.2

Table 5 - Cont.
Page 3

Plate Number	Slit Position	T(0.5) °K	W ₀ (0.5) mÅ	σ_{ϕ} Percent	b	T(b)	W ₀ (b)	σ_{ϕ}
T650b	Std+17	229 ²³⁴ 225	11.3	1.2	0.669	247 ²⁵⁰ 245	8.1	0.6
T650c	Eq -6	236 ²⁴¹ 231	11.5	1.3	0.687	249 ²⁵² 246	8.0	0.7
T651a	N +32	236 ²⁵² 231	11.2	2.1	0.749	262 ²⁶⁴ 259	6.9	0.9
T651b	S -37	233 ²³⁸ 227	11.5	1.4	0.649	251 ²⁵⁵ 248	8.5	0.9
T651c	Std+37	235 ²⁴⁰ 230	11.4	1.3	0.566	244 ²⁴⁸ 240	9.9	1.0
T654b	Std+12	237 ²⁴⁴ 230	9.8	1.7	0.692	258 ²⁶² 255	6.7	1.0
T655b	Std+13	226 ²³² 220	10.3	1.5	0.648	244 ²⁴⁷ 240	7.7	1.0
T657b	Std+15	230 ²³⁶ 225	10.7	1.4	0.695	247 ²⁴⁹ 245	7.4	0.6
T658b	Std+15	234 ²⁴¹ 228	11.1	1.5	0.702	257 ²⁶⁰ 254	7.4	0.9
T660b	Std+12	222 ²²⁷ 217	10.9	1.3	0.699	251 ²⁵³ 248	7.2	0.7
T660c	Eq +10	237 ²⁴¹ 233	9.8	0.9	0.574	245 ²⁴⁸ 242	8.4	0.7
T661b	Std	241 ²⁵¹ 232	10.5	2.2	0.713	262 ²⁶⁶ 258	6.8	1.1
T661c	Eq +0	224 ²²⁹ 220	11.5	1.2	0.685	248 ²⁵⁰ 246	7.8	0.6
		σ_{int} σ_{ext}				σ_{int} σ_{ext}		
average	Eq	236±2.2 3.3	10.7	0.5	0.659	254±1.3 2.6	7.7	0.3
average	N	227±3.2 4.0	11.1	0.8	0.679	249±1.8 5.2	7.9	0.5
average	S	234±2.6 2.1	11.0	0.6	0.633	249±1.5 2.8	8.5	0.4
average	L	218±5.4 4.3	10.7	1.6	0.694	240±3.1 1.2	7.5	1.0
average	T	226±5.5 4.0	11.3	1.4	0.640	245±3.6 3.5	8.6	0.9
average	Std	228±1.6 2.2	10.8	0.4	0.688	248±0.8 2.1	7.5	0.2
average	all	230±1.3 1.5	10.9	0.25	0.671	249±0.6 1.4	7.8	0.15

Table 6

Summary of Measurements of Temperatures
over different areas of Venus

Band head, Å	reference	Slit Alignment				ΔT °K
		parallel T(°K)	to equator n	pole-to-pole T(°K)	n	
7820	Present results	251±2	(24)	247±2	(23)	4±3
7820	Young et al, 1971	250±4	(4)	240±2	(11)	10±5
7820	Schorn et al, 1969	253±4	(7)	246±3	(11)	7±5
8689	Schorn et al, 1974	242±2	(7)	248±2	(23)	-6±3
8689	Young et al. 1969	239±3	(15)	236±4	(15)	3±5
10488	Young et al, 1970	238±3	(6)	237±3	(25)	1±4
10627	Schorn et al, 1971	274±15	(6)	234±3	(25)	40±15
10362	Schorn et al, 1970	-----		237±3	(15)	---
12030 12177	Young et al. 1970	-----		236±5	(10)	---

Table 7
Variation in temperature and CO₂
Abundance from the average
value for Each region on Venus

Plate Number	Slit Position	Date 1972	W _O (0.5) mA	T(b) °K
T622	Std	IX 17.556	+0.5	-12
T624a	T	IX 17.731	+0.5	- 4
T625a	Std	IX 18.549	+0.3	+15
T625b	S	IX 18.598	+0.5	- 6
T625c	N	IX 18.620	+0.9	-10
T627a	Std	IX 19.634	0.0	- 7
T630a	Std	IX 20.629	-0.3	- 5
T630b	N	IX 20.653	-1.3	+17
T630c	NN	IX 20.677	+1.4	- 1
T631a	Eq	IX 20.722	-0.4	+ 6
T631b	S	IX 20.759	-0.3	- 6
T633a	Std	IX 21.630	+0.4	- 3
T633b	Eq	IX 21.667	+0.3	- 6
T636a	Std	IX 23.615	+0.9	+16
T636b	S	IX 23.654	-0.3	+ 1
T636c	N	IX 23.692	-0.6	- 1
T640a	Std	IX 25.615	+0.9	- 9
T640b	Eq	IX 25.640	+0.1	+11
T640c	S	IX 25.663	-0.1	+15
T641a	Eq	IX 25.701	-0.7	+11
T641b	Eq	IX 25.738	-0.4	+12
T641c	L	IX 25.770	0.0	+ 1
T644a	Std	IX 26.614	+0.1	- 9
T644b	L	IX 26.647	-0.2	+ 2
T644c	T	IX 26.691	0.0	+ 3
T645a	Eq	IX 26.747	+0.4	+ 3
T645b	N	IX 26.780	+0.4	-23
T645c	S	IX 26.803	+0.3	- 4
T647b	N	IX 27.636	-1.1	+ 8
T647c	Eq	IX 27.659	-0.4	- 2
T648a	S	IX 27.684	-0.5	+ 1
T648b	Std	IX 27.708	-0.5	0
T649b	Std	IX 28.778	-0.3	- 9
T650b	Std	IX 30.562	+0.5	- 1
T650c	Eq	IX 30.586	+0.8	- 5
T651a	N	IX 30.616	+0.1	+13
T651b	S	IX 30.639	+0.5	+ 2
T651c	Std	IX 30.662	+0.6	- 4
T654b	Std	X 1.714	-1.0	+10
T655b	Std	X 2.565	-0.5	- 4
T657b	Std	X 3.608	-0.1	- 1
T658b	Std	X 4.575	+0.3	+ 9
T660b	Std	X 5.550	+0.1	+ 3
T660c	Eq	X 5.575	-0.8	- 9
T661b	Std	X 7.609	-0.3	+14
T661c	Eq	X 7.637	+0.8	- 6







































